Installation manual for Low-Cost Polyethylene Tube Digesters

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Edited by: Marc Lüer

Contact: Marc.Luer@t-online.de

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Internet: www.endev.info

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Contact: Andreas.Michel@gtz.de

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Installation manual for Low-Cost Polyethylene Tube Digesters

This document explains step by step the construction, installation, operation and maintenance of a Low-Cost Polyethylene Tube Digester. This manual is based on the practice and experience of the GTZ / EnDev – project in Bolivia and the manual “Biodigestores Familiares – Guía de diseño y manual de instalaciòn” written by Jaime Martí Herrero. Special thanks go to Jaime Martí, Gabriel Paco and Andreas Michel for the assistance and the interchange of experience.

Marc Lüer

1. Introduction of the technology

In the case of the Low-Cost Polyethylene Tube Digester model which is applied in Bolivia (Peru, Ecuador, Colombia, Centro America and Mexico), the tubular polyethylene film (two coats of 300 microns) is bended at each end around a 6 inch PVC drainpipe and is wound with rubber strap of recycled tire-tubes. With this system a hermetic isolated tank is obtained (figure 1). One of the 6" PVC drainpipes serves as inlet and the other one as the outlet of the slurry. In the tube digester finally, a hydraulic level is set up by itself, so that as much quantity of added prime matter (the mix of dung and water) as quantity of fertilizer leave by the outlet.
At the moment Low-Cost Polyethylene Tube Digesters in Bolivia have costs between 93, - € and 148, - €. To operate a digester, the producer has to charge it day to day with 20 kg of cow dung (or other animal dung), mixed with 60 liters of water. Once the digester starts its operation (between 30 to 60 days), it produces around 4 - 5 hours of biogas daily, for cooking or other applications like use of gas lamps. Furthermore the digester provides daily 80 liters of ecologic fertilizer, which helps to increase the production of agriculture. The digester system has a pressure between 15 cm - 20 cm of water column.
The construction and installation of a polyethylene tube digester, need just one morning, assumed that the trench is excavated, ready and the materials are available. The biogas supply line up to the kitchen needs some hours more, according to the challenge and distance of each case.

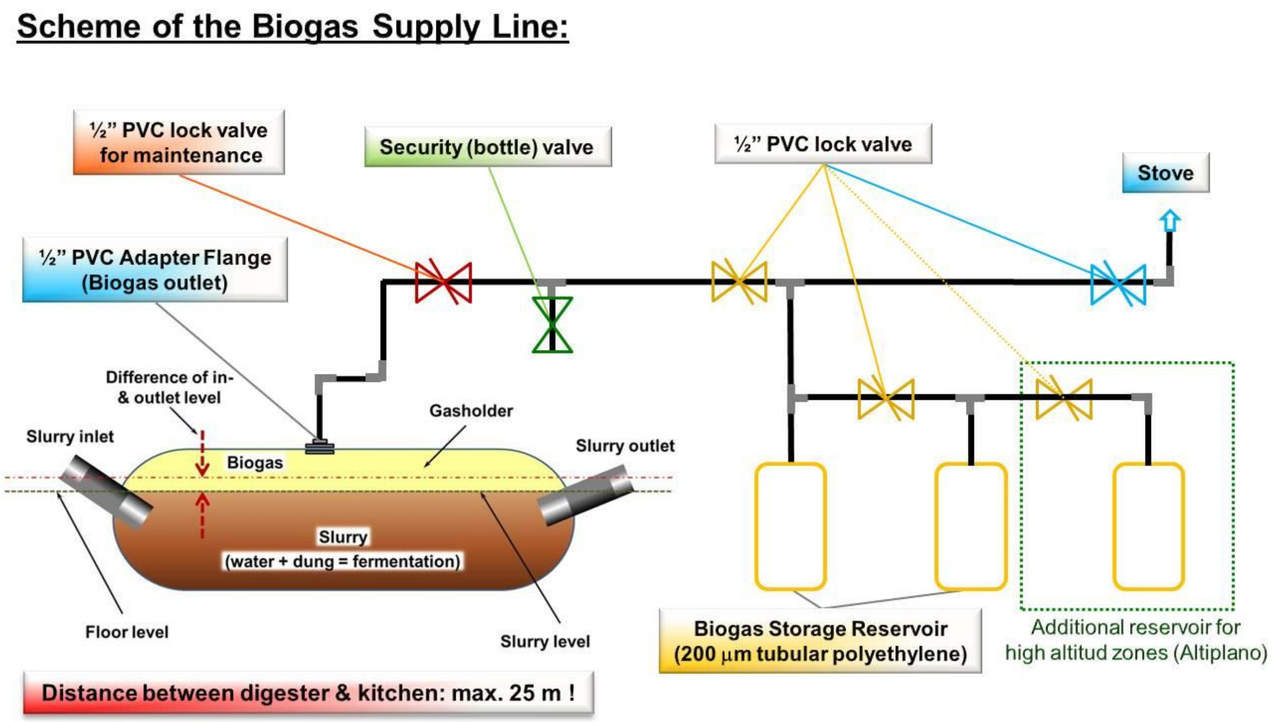

Figure 1: Scheme of the complete tube digester system

2. The 3 tube digester types of Bolivia

As mentioned before, the manual is based on the experience of the GTZ / EnDev – project in Bolivia. So the three types of tube digesters from Bolivia will assist like base-models.

Low-Cost Polyethylene Tube Digester Altiplano	
Climate:	Soft summers and hard winters. Freezing temperatures during winter nights. Mean ambient temperature 0 - 15ºC
Meters above sea level:	3.000 – 4.500 m_{asl}
Total Volume:	7,79 m^3
Liquid Volume:	5,84 m^3
Gasholder Volume:	1,95 m^3
Roll width:	1,75 m
Digester-Diameter (D):	1,11 m
Length of the digester (L):	8,0 m
Ratio L/D:	7,17
Low-Cost Polyethylene Tube Digester Valley	
Climate:	Soft summers and winters. No freezing temperatures during winter nights. Mean ambient temperature 15 – 20 ºC
Meters above sea level:	2.000 – 3.000 m_{asl}
Total Volume:	4,70 m^3
Liquid Volume:	3,52 m^3
Gasholder Volume:	1,17 m^3
Roll width:	1,5 m
Digester-Diameter (D):	0,96 m
Length of the digester (L):	6,5 m
Ratio L/D:	6,8
Low-Cost Polyethylene Tube Digester Tropics	
Climate:	Warm summers and soft winters. Tropic climate. Mean ambient temperature over 20 ºC
Meters above sea level:	0 – 2.000 m_{asl}
Total Volume:	3,63 m^3
Liquid Volume:	2,72 m^3
Gasholder Volume:	0,91 m^3
Roll width:	1,5 m
Digester-Diameter (D):	0,96 m
Length of the digester (L):	5,0 m
Ratio L/D:	5,3

Table 1: Comparison of the three Low-Cost Polyethylene Tube Digester types of Bolivia. The three types have a similar biogas-outlet, also slurry in- and outlet

3. Necessaries materials and tools

First of all, it is to set the tool kit and the necessary materials for the construction and installation of a tube digester up to the kitchen.
All the necessary materials for the construction of a tube digester should be deliverable in the markets of any country.
The most particular material is the tubular polyethylene, which should be ordered with a thickness of 300 microns (µm) and with the color "black smoke", which it is noted as more resistant against the solar radiation. Another advantage of a non transparent material is, that any light is able to reach the slurry, because light clams the process of the methane production. The materials for the construction of a Low-Cost Polyethylene Tube Digester are listed in the following tables:

3.1. Materials

Materials	
Tubular Polyethylene - 300 microns [µm] black smoke (UV-filter) width of roll: 1,75 m (Altiplano) 1,50 m (Valley & Tropics) <u>Number:</u> 18 m (Altiplano) 15 m (Valley) 12 m (Tropics)	
<u>Greenhouse for High Altitude-Zone</u> Tubular Polyethylene - 250 microns [µm] - transparent width of roll: 2,0 m <u>Number:</u> 9 m <u>Protection for Valley- and Tropics Zones</u> Half shade red 50 % (8,5 m x 2 m) (Valley) Half shade red 50 % (7,0 m x 2 m) (Tropics)	*No picture*
PVC drainpipe - 6" <u>Number:</u> 2 units of 1 m each one	
Rubber strap - produced from old automobile tire-tubes 4 - 5 cm width and as long as possible (this is for the winding of the inlet and outlet of the sludge) <u>Number:</u> 60 m	

Table 2: Materials for the tube digester construction Part 1

Materials	
PVC tube bend ½” <u>Number:</u> 4 units	
PVC T-fitting ½” <u>Number:</u> 4 units	
PVC lock valve ½” <u>Number:</u> 5 units	
PVC universal coupler ½” <u>Number:</u> 2 units	
PVC adapter flange ½” <u>Number:</u> 4 units (High Altitude) 3 units (Valley & Tropics)	
Tubular Polyethylene - 200 microns [µm] - transparent width of roll: 1,0 m 3 biogas-reservoirs (2,5 m each one) (Altiplano) 2 biogas-reservoirs (2,5 m each one) (Valley & Tropics) <u>Number:</u> 7,5 m (Altiplano) 5 m (Valley & Tropics)	
PVC - tube ½” (irrigation tube) <u>Number:</u> 25 m	

Table 3: Materials for the tube digester construction Part 2

Materials	
Teflon – band <u>Number:</u> 2 units	
Steel wool (SH_4 filter) <u>Number:</u> 1 unit	
Biogas - burner (Example - picture) <u>Number:</u> 1 unit	
PVC plug for T- tube ½” <u>Number:</u> 1 unit	

Table 4: Materials for the tube digester construction Part 3

3.2. Additional materials without specific costs

Material	Use
Straw or fine sand	For the floor of the trench
Sacks of jute or old plastics	For the lateral walls of the trench
Metal wire and pricks	To fix the inlet and outlet pipes
Bars of wood with 2m length	For the greenhouse in high altitude zones
Nails	To fix the sacks for the lateral walls of the trench
1.5 l or 2 l plastic refreshment bottle	For the security valve
Adobe	For the greenhouse walls in high altitude zones

Table 5: Additional materials

3.3.Tools and auxiliary materials

Tools and Auxiliary Materials	
Tarpaulin (4 m x 9 m)	
Transparent flexible tube (to level the inlet and outlet tubes) ∅ ¼” - ½” 12 m length	
Shear	
Measuring tape 8 m – 10 m	
Saw	
Pipe tongs	
Pipe tap ½” for outside thread	
Screw driver	

Table 6: Tools

4. Selection of the location where the tube digester is installed

The tube digester is installed in a central position between the kitchen and the place where the livestock sleep, in order that the collection of the fresh dung is most easily as possible and that the supply line is as short as possible. It is important that the digester is placed above flooding levels. The maximum distance between tube digester and kitchen should not exceed ***25 m*** in order to minimize the pressure leakage.
Because the tubular polyethylene is flexible, it is necessary to construct a "cradle" which will accommodate the reaction tank, so that a trench is excavated.
It is important to consider, that the trench of the tube digester should not interrupt the way of the livestock or persons.
The trench in high altitudes (3.000 – 4.500 m above sea level), like e.g. the Bolivian Altiplano, should be orientated alongside from east to west. (See chapter “Dimensions and completion of the trench”)
In valley-zones (2.000 – 3.000 m_{asl}) and tropical zones (0 – 2.000 m_{asl}), the orientation is not so important, because the solar radiation doesn´t play an important role in the direct heating of the tube digester.
In the valley-zones (2.000 – 3.000 m_{asl}), the trench should be installed in sunny zones, never in shadows, because the solar radiation helps to heat the terrain where the tube digester is placed. As mentioned before, the digester self is to protect with a half shadow red or better a roof.

In the tropical-zones (0 – 2.000 m_{asl}), there is no need to install the digester in a sunny place due to the warm clime conditions. But it is important to protect the digester with a half shadow red or much better a roof.

Above the tube digester must not be limbs of trees, because they could broke by the wind and damage the polyethylene bag. In high altitudes, it is important that the shadow of any tree doesn´t reach the greenhouse.

5. Dimensions and completion of the trench

Once selected the location of the tube digester, the trench is excavated. The dimensions of the trench depend on the size of the tube digester.
The four trench walls are inclined to avoid that they crumble and to support the form of the digester (Figure 2).

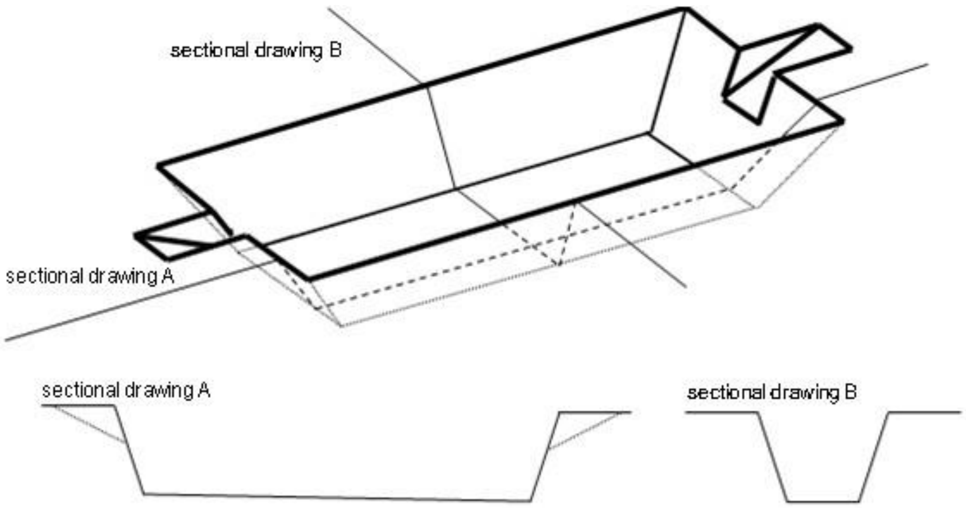

Figure 2: Trench form with two sectional drawings

The dimensions for the three Bolivian tube digesters types are described below.

5.1. Type 1 – High Altitudes (3.000 – 4.500 m$_{asl}$)

The biodigester for the Bolivian Altiplano is enclosed in a greenhouse of polyethylene (250 microns), supported by two lateral adobe walls of 40 cm thickness (figure 4) above the hole length of the trench. This lateral walls accumulate the heat of the greenhouse effect, that with freezing temperatures during winter nights, they maintain the digester in function, by the own high thermal inertia. The trench has a length of 8 m and the channels for the in- and outlet have an inclination of around 40° (Figure 3).

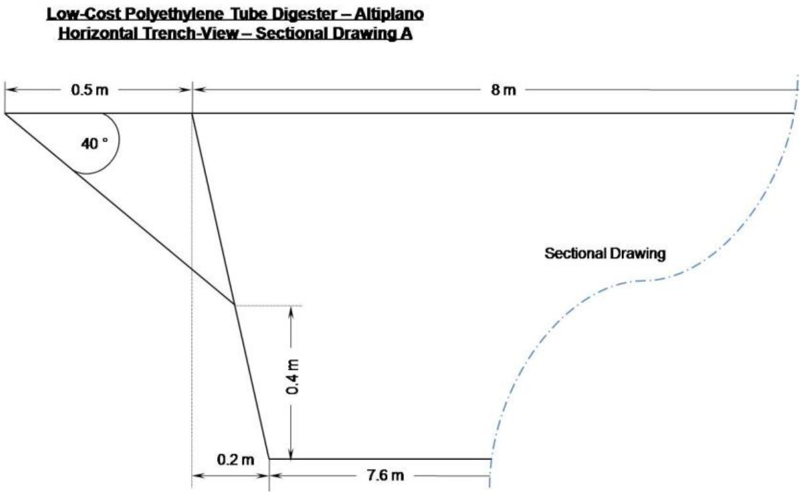

Figure 3: Trench profile for the in- and outlet of the tube digester in high altitudes

The higher adobe wall is orientated to the south (this for the south hemisphere) and the lower one to the north. Above this two walls the greenhouse is supported. Once the digester is installed, it is important to close the two narrow sides of the greenhouse with adobe too.

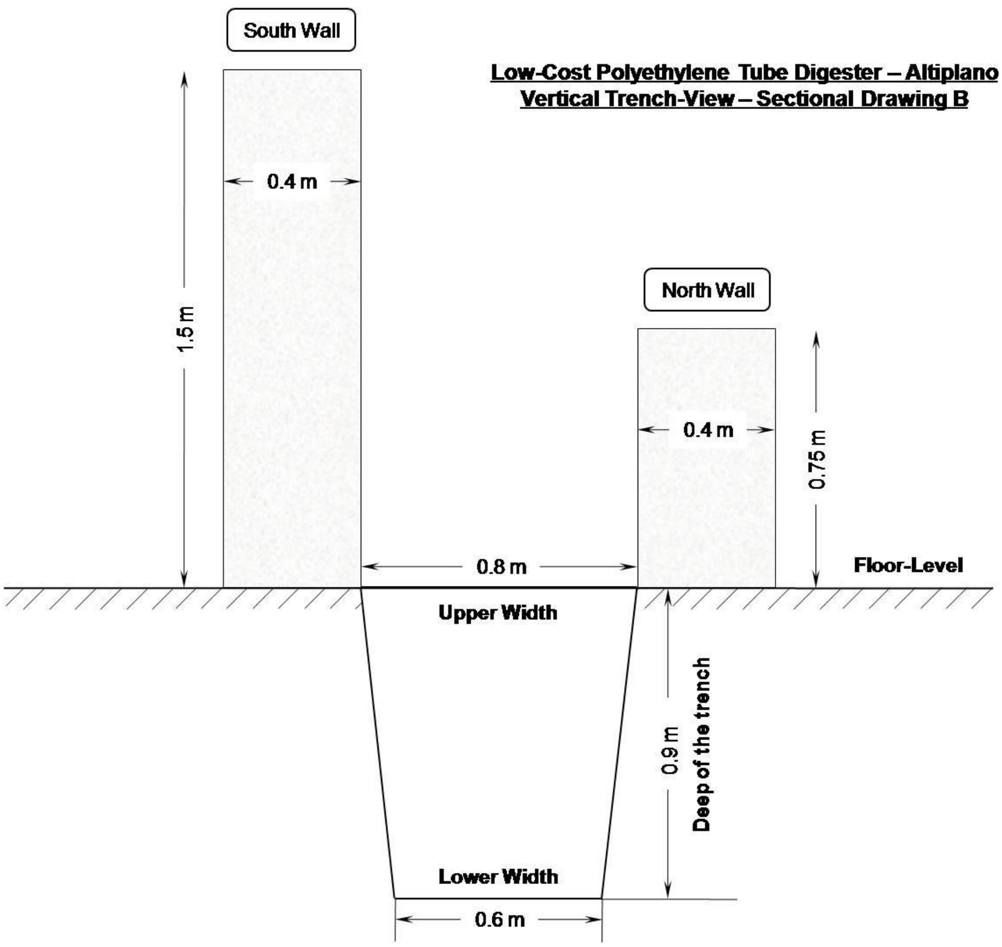

Figure 4: Trench profile sectional drawing B with laterals adobe walls

Figure 5: Open and closed trench for a tube digester in the Bolivian Altiplano

5.2. Type 2 – Valley-Zones (2.000 – 3.000 m_{asl})

For the valley-zones there is no need to install the adobe walls. The trench has a length of 6, 5 m and the channels for the in- and outlet have an inclination of around 40° (Figure 6). The dimensions of the trench profile are seen in figure 6 & 7.

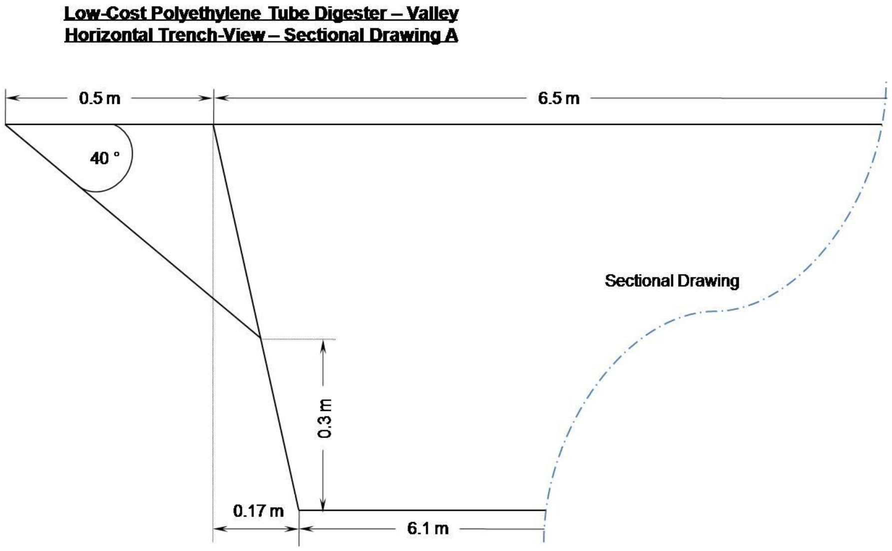

Figure 6: Trench profile for the in- and outlet of the tube digester in valley-zones

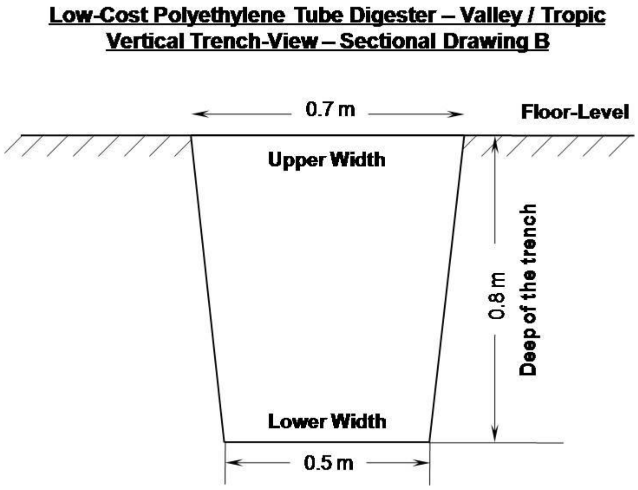

Figure 7: Trench profile sectional drawing B of the tube digester in valley-and tropical zones

5.3. Type 3 – Tropical-Zones (0 – 2.000 m_{asl})

For the tropical-zones there is no need to install the adobe walls too. The trench has a length of 5, 0 m and the channels for the in- and outlet have an inclination of around 40° (Figure 8). The dimensions of the trench profile are seen in Figure 7 & Figure 8.

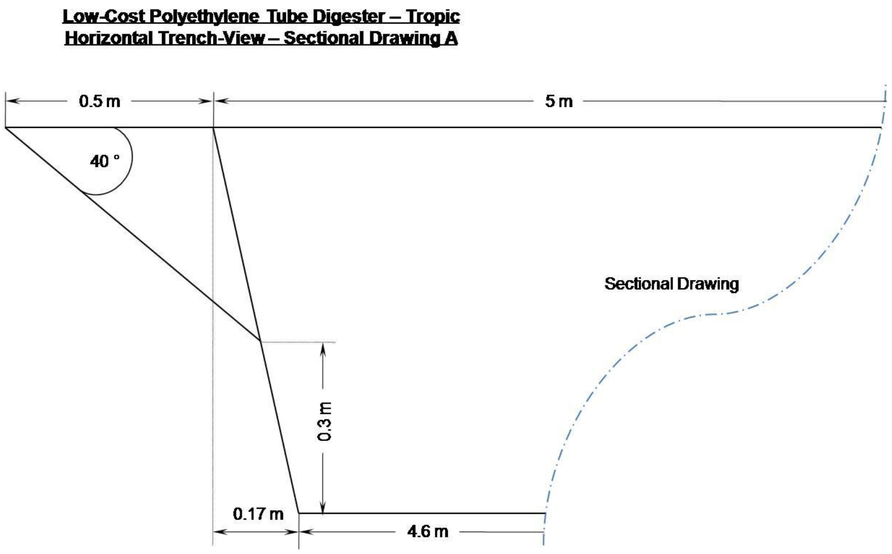

Figure 8: Trench profile for the in- and outlet of the tube digester in tropical-zones

5.4. General steps for the completion of the trench

- Once the work is made, the trench is cleaned from stones and roots, to avoid that they damage the tube digester.
- After that, the lateral walls are lined with old sacks of jute or old greenhouse plastics to protect the polyethylene of the tube digester.
- The floor of the trench is covered with fine sand, straw or the mentioned old sacks. Sometimes dung of cows or sheep is used too, with the effect of an increase of temperature for the first days.
- The trench shouldn´t have an incline. The maximum allowed incline is 5 % over the whole length.

6. Construction of the tube digester

Once the trench is excavated and completed, the construction of the tube digester can start. The necessary materials for the construction are the followings:

- Tubular polyethylene roll (300 microns)
- Rubber strap - produced from old automobile tire-tubes
- 6” drainpipes for the inlet and outlet of the slurry
- PVC adapter flange ½” for the biogas outlet
- 1.5 m of ½” PVC tube
- 1 unit of ½” PVC lock valve

The required tools and auxiliary materials are:

- Saw
- Pipe tap ½” for outside thread
- Pipe tongs
- Teflon
- Shear
- Tarpaulin (4 m x 9 m)

It is important to realize the construction of the tube digester, over a ground free of stones and objects, which could damage the polyethylene of the digester. So it is recommended to extend a tarpaulin like a working surface.

6.1. The double 300 microns polyethylene coat

The first is to cut two bags of the 300 microns polyethylene in the needed size. At this point it is to mention, that the length of the plastic have 1, 0 m more than the final length of the tube digester. This is needed for the folding of the plastic at the slurry inlet and outlet pipes (0, 5 m each side).

Zone	Tube digester length	Tube length
High Altitude (3.000 – 4.000 m_{asl})	8 m	9 m
Valley (2.000 – 3.000 m_{asl})	6,5 m	7,5 m
Tropics (0 – 2.000 m_{asl})	5,0 m	6 m

Table 7: Digester and tube length

One polyethylene bag is to extend completely on the floor (over a tarpaulin), and the second one is to introduce carefully in the first bag. A person has to cross over the whole length inside the extended bag, without dropping the end of the inside bag (Figure 9). The idea is to have just “one” tube with a double coat. It is important to avoid inside wrinkles and to make the two coats coincident.

Figure 9: To make the double coat of the polyethylene, somebody has to cross inside the bag and to carry the second bag over the whole length.

6.2. The Biogas outlet

When the tube with the double polyethylene coat is ready, the biogas outlet with the PVC ½” adapter flange is made.
A small cut through the double coat of plastic is made (Figure 10). It is fair to make the cut in the middle of the tube digester, but about 0, 5 m closer to the slurry inlet side. This is made, because the trench could have a small incline, so that the gasholder is generating itself closer to the inlet and by this way the biogas can leave out better.

Figure 10: For the mounting of the flange, a cut in the central part of the double coat tube is made. The tightened flange seals the biogas outlet with some rubber pads.

The cut through the two good covered plastic coats is made, during a finger forms a small triangular “tent” and then the pike is cut. It is better to make a small cut, because if to introduce the flange is not possible, the cut is amplified carefully, step by step, until the flange can pass.

Once made this, the rubber pad is fixed and the screw-nut is tightened, by using the manual force first and then the pipe tongs to fit it. Therefore the double coat is held captured between two rubber pads, tightened by the thread between the stud-bolt and the screw-nut.

To finalize the biogas outlet, a piece of the ½” PVC tube of 1, 5 m length is cut. Then a thread at both ends with the ½” pipe tap (for outside thread) is made. With Teflon at both ends (at least 5 turns in the opposite direction of the thread), the tube is screwed with the biogas outlet (flange) and at the other end fixed with a ½” PVC lock valve.

6.3. The slurry inlet and outlet pipes

After finishing the biogas outlet, the two ends of the double coat polyethylene tube are closed, by strapping them with the 6” drainpipes of the slurry in- and outlet. Both cases are identical.

Figure 11: The drainpipe has a length of 4, 0 m normally, so the pipe is cut into pieces of 1, 0 m length. It is to protect the mouths of the in- and outlet pipes, which are introduced inside of the tube digester.

The 6” PVC drainpipe, which has a length of 4, 0 m normally, is cut into pieces of 1, 0 m length. The mouths of the pipes, which are introduced inside of the tube digester, are to protect at first (Figure 11). This is made, because the normally rough cut does not damage the polyethylene, during the strapping and manipulation of the pipes.
For that it is enough to wind rubber strap over the mouth of the pipe and to cover the cut with some millimeters. The rubber strap is gagged by itself.
The protected pipes are fitted in the both ends of the double coat digester tube about 80 cm, so that about 20 cm are outside.
Now it is to reposition the plastic, to be able to fix it with the in- and outlet pipes. Therefore a lateral of the plastic is picked up and bended in form of an accordion (Figure 12). The plastic is bended so far as the polyethylene “accordion” abuts on the pipe. In this manner it is to proceed with the other side too. It is helpful that the bends don´t generate crinkles among each other and that the bends are long and opening to the length of the rest of the tube digester.
If this is done with the both sides, 50 cm from the end of the polyethylene is taken and from this point the rubber strap of old automobile tire-tubes is wound. This mean that 30 cm of the in- and outlet pipes stay inside the tube digester, 50 cm are wound and 20 cm are outside.
The strap is wound, that every turn covers with the half broadness the former one. In this manner the strap is moved up the pipe step by step. The winding has to be strong. It is very important that the strap keeps tense and covers the former turn. Once the 50 cm of plastic is wound, 10 cm more is wound about the pipe. In this way it is to precede with the inlet also the outlet.

After this step the tube digester is ready for the installation in the trench. From the construction of the double coat polyethylene tube up to the slurry in- and outlet, above two hours are needed, depending on the experience of each one.

Figure 12: To fix the inlet and outlet pipes with the digester, it is to pick up the lateral of the plastic, to bend them in form of an accordion and then to wind them with the rubber strap.

7. Installation of the tube digester

The installation of the tube digester is to realize with at least two persons, better with more. The most important is, to protect the digester about scratching with the floor or any object during the displacement. This is a serious thing, because the polyethylene doesn´t serve anymore with a leakage.

7.1. Introduction into the trench

The constructed tube digester is put in the prepared trench, with the lined walls and the padded floor. The best is to pitch the digester and to transport it with some persons like a “train” to the trench (Figure 13). Every person has to care for that the plastic never scratch’s anything. So the best is to flip the lateral borders of the tube digester and to fold them to the middle. In this way the digester is inserted into the trench.

Figure 13: The digester is put very carefully into the trench. The displacement of the tube digester is the most critical situation during the whole installation process.

Once the digester is standing in the trench, it is useful to check that the interior part doesn´t have crinkles by drafting the both ends of the tube digester and if is necessary to place somebody into the trench. Later crinkles can´t removed, because the weight of cubic meters of slurry inside the tube digester prevents this.

7.2. The level of the inlet, outlet and the slurry

The profoundness of the trench is corresponding with the maximal level which will reach the slurry inside the tube digester. In order that this is the level, it is necessary that the outlet, the external mouth of the pipe, is on this level. To calculate the level, a transparent flexible tube is used.

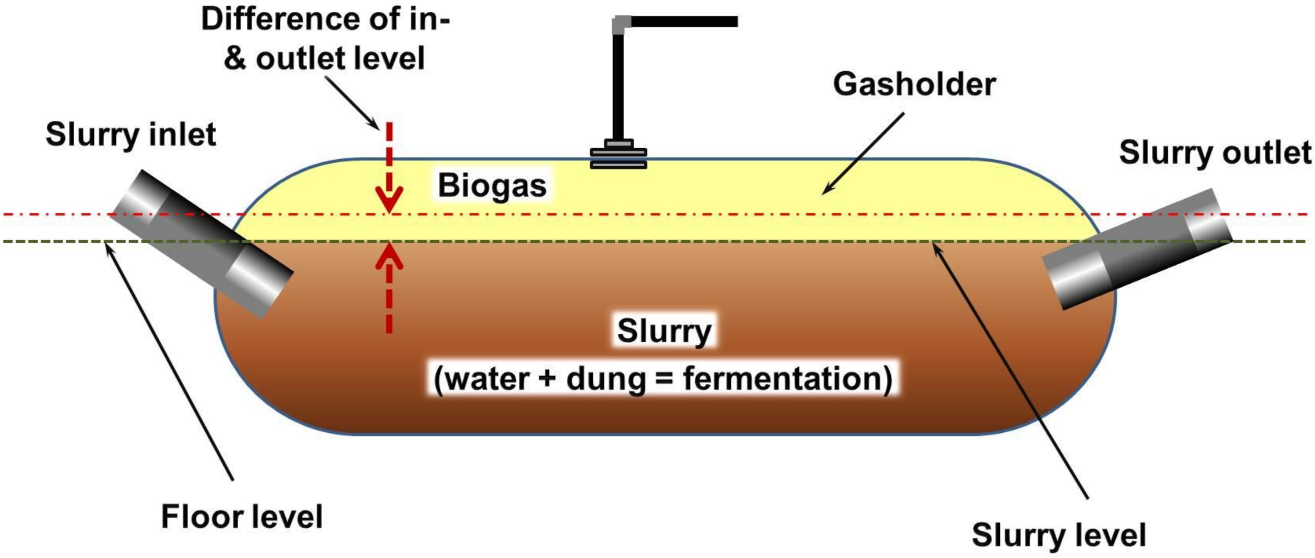

Figure 14: It is very important that the mouth of the slurry outlet is in the same level as the profoundness of the trench. The slurry inlet is to fix, so that the middle part of the winding coincides with the level of the outlet.

Once that the interior part of the outlet mouth is on the level, that the tube digester will fill-up to the same level with the profoundness of the trench, the slurry inlet is fitted. In this case the inlet is more lifted and the slurry level (which coincides with the outlet level) should be in the middle of the 50 cm winding of the inlet pipe (Figure 15). If the levels are determined, the pipes are fixed, so that they can't move anymore. The charging of the digester drafts the pipes inside the trench and for that it is necessary to fix them.
For that small holes in the pipes are made with the pike of a knife or a shear, and a prick is driven in a distance of a half meter. Metal wire is passed through the holes and strapped with the prick.
Once made this, it is recommended to cover the rubber strap winding of the inlet and outlet with old sacks, so that the sun can´t make the strap refractory.

Figure 15: To measure the levels of the outlet, it is easy to use a transparent flexible tube full of water, which indicates the level.

8. The first substrate charge

After the installation of the tube digester, the first charge of the mix of dung and water is realized.

It is important to have a huge quantity of fresh dung and fill up the digester up to the interiors mouths of the inlet and outlet, so that they are blocked with the slurry. In the moment when the interior mouths are closed with the slurry, the air doesn´t have any access to the interior of the tube digester. This is an essential point in the production of methane.
It is recommended to accumulate fresh dung seven days before the installation, to have enough prime material at the day of the first charge.

Normally it is enough to accumulate seven barrows of fresh dung and mix them with enough water, so that the slurry enters slippy into the digester and infusing water until the interior mouths of the inlet and outlet are covered.

After the first charge, it is to feed the tube digester with the approximate daily charge the next day. For the submitted model it is to mix 20 kg of cow-dung with 60 l of water.

9. Closing of the greenhouse in case of the high altitude zones

In the case of the high altitude zones, like the Bolivian Altiplano, it is to close the greenhouse after the first charge of the tube digester.

The first is to fit some bars of wood like in the Figure 16. These bars can be roundly or flat, normally with a length of 2 m. For a tube digester of 8 m, it is to spend 9 bars and fit them each meter. It is recommended to fix the bars with the adobe walls and that the bar ends overlap the lateral. In this way, the greenhouse is supported above the walls.

Then it is to fix the polyethylene for the greenhouse as much as possible hermetically. It is possible to use natural insulations, like straw. The fitting of the insulation should be outside the adobe walls. In this way the walls can store the heat of the greenhouse and the insulation doesn´t let it out.

Figure 16: In the high altitude zones a greenhouse is fitted. First it is to fit the bars on the adobe walls and then the greenhouse above the bars.

10. The biogas supply line

Once the tube digester is installed, it is the moment to continue the biogas supply line from the tube digester to the kitchen.
From the ½" PVC lock valve of the biogas outlet, the biogas supply line is continued with the ½" PVC tube (irrigation tube) up to the kitchen. The supply line is installed in the air, thus the tube is fixed elevated at pricks, or supported in a certain high above a wall. This is done to have an access to the line. The maximum distance between the tube digester and the kitchen should not exceed 25 m. The line is made directly; bends and couplers are used, when it should be precise. It is very important to connect the security valve near by the biogas outlet and the reservoirs near by the kitchen.

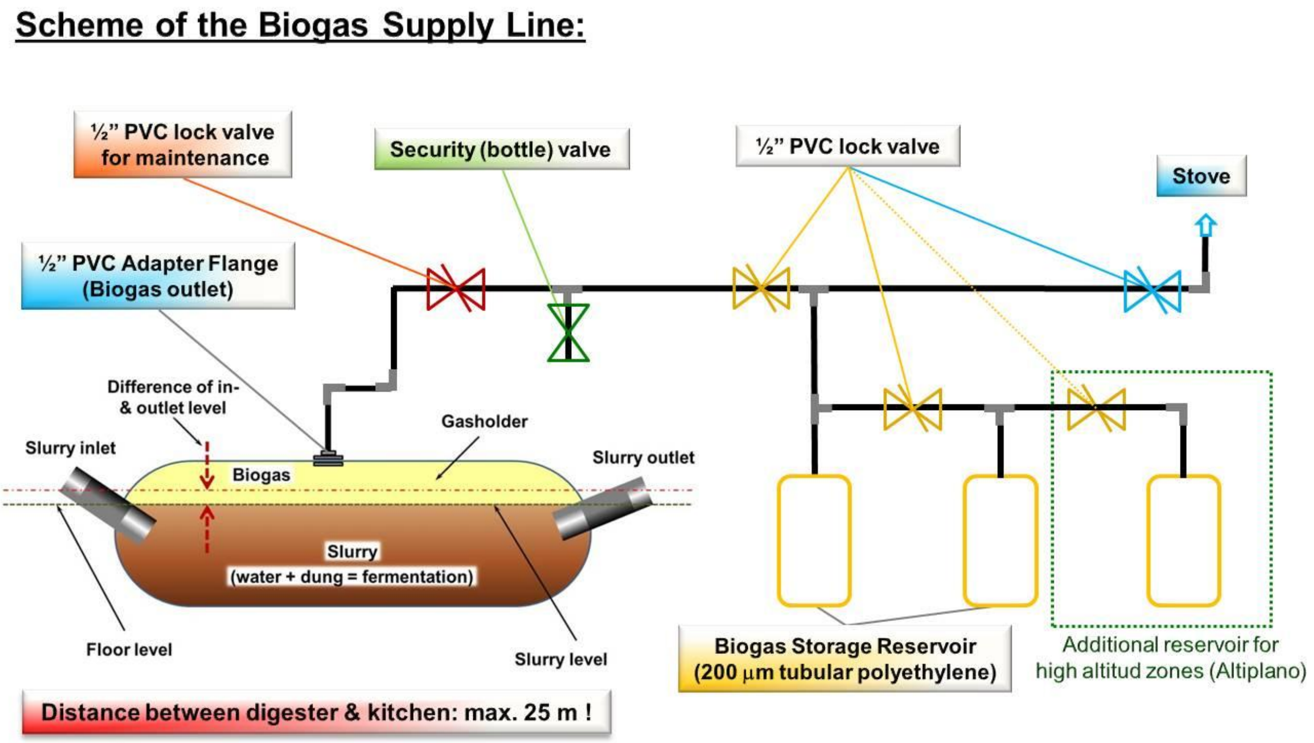

Figure 17: Scheme of the biogas supply line.

10.1. Accumulation of water

It is important to fit the tube elevated, never buried, because the accumulation of water which can appear. The digester is full of water, mixed with dung. This water evaporates and condensed in the tube. This can block the supply line and avoid that the biogas reach's the kitchen. Sometimes it is inevitable, that the supply line has "valleys", lower points where the water will accumulate.
At these points a t-fitting (Figure 18), closed by a screw plug, is installed. In this manner, it is possible to open the plug and to let out the accumulated water. It is possible too, to make the supply line ever with an incline, so that the condensed water flows to the security valve, or another point where it is possible to dewater the biogas supply line.

Figure 18: At the lower point of the biogas supply line a t-fitting with a screw plug is installed. In this way it is possible to dewater the blocked supply line.

10.2. Security valve

The security valve is installed near by the tube digester. In this manner it is possible to review the water level during the daily charging. The valve allows that the biogas can escape, during insufficient consume.

The security valve is produced with a 1, 5 l or 2, 0 l PET refreshment bottle (Figure 19). A hole in the superior part is made, to be able to refill the bottle with water, when it begins to evaporate. After the PVC lock valve of the biogas outlet, a t-fitting is integrated in the line, so that the biogas is able to flow to the kitchen. The open outlet of the t-fitting is connected with a 20 cm long ½" PVC tube, which is introduced in the plastic bottle. The bottle is fixed with metal wire at the t-fitting and filled up with water, so that the tube is dipped in 15 – 20 cm of water. This depends on the distance between the tube digester and the kitchen, the used stove and the altitude of the climate zone. The biogas user has to adjust the optimal maximum pressure himself (but no more than 20 cm of water column).

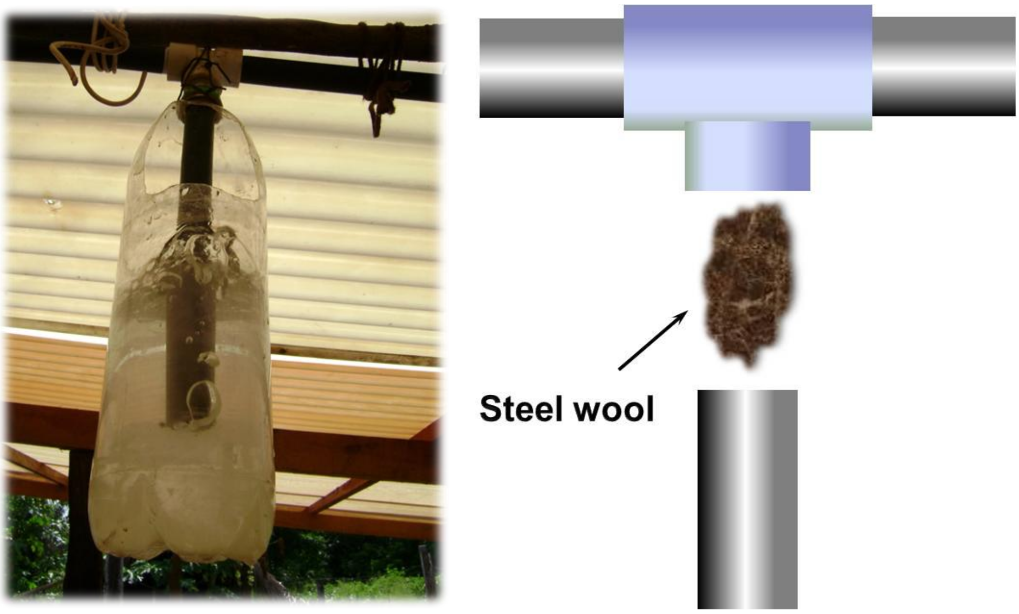

Figure 19: The security is fitted near by the tube digester, to be able to control daily the water level. In the t-fitting a steel wool is fitted, like a basic hydrogen sulfide filter.

The security valve controls the maximum pressure of the system (depends on the interior water column). It is important that the lock valve of the biogas outlet before the security valve every time is unlocked. Just for the short moment of maintains, is allowed to lock the valve. It is recommended to fix the lock valve, so that it is impossible to manipulate the valve by an oversight. If the valve is not secured, the risk persists that the valve stay locked and the biogas, which is produced in the tube digester, doesn´t have a way to escape and achieves to burst the digester.
Inside the t-fitting a piece of steel wool is fitted (Figure 19), which serves like a basic hydrogen sulfide filter, to reduce the typical smell of biogas (like rotten eggs). On the other side it serves like a "fire-tramp" and prevents that an external combustion can extend through the biogas supply line. It is recommended to change the steel wool around every 6 month.

10.3. The biogas storage reservoirs

The biogas reservoirs are an additional storage to the gasholder of the tube digester and serve to increase the biogas pressure, when it begins to decrease. The reservoirs are installed closely to the kitchen, but not directly beside the fire or rather the biogas stove. Always the reservoirs are protected against the sun and the wind or installed under a roof or e.g. in a store.
In the case of Bolivia it has transpired, that the installation of 3 reservoirs in the Altiplano zones or 2 in the valley and tropics zones is beneficial. In the Altiplano one reservoir more is installed, because the production of biogas is associated with an extensive major effort, so that is assured to be able to absorb all the produced biogas.

10.3.1. The construction of the biogas storage reservoirs

The reservoirs are made with the 200 microns tubular polyethylene (Table 3 / page 7). A 2, 5 m long bag for each reservoir is cut and as the tube digester biogas outlet, a ½” PVC adapter flange (in the same method as in the chapter 6.2 is described) is fitted in the lower part of each reservoir (Figure 20: Bending the biogas storage reservoir with biogas outlet / flange).

Figure 20: Bending the biogas storage reservoir with biogas outlet / flange

Once the flange is tightened, the ends of the reservoir are bended like an accordion and wound with the rubber strap around a piece of log wood or an old plastic pipe with a diameter of about 3” – 2” and a length of about 20 cm, so that the reservoir is closed and sufficient sealed that any biogas can leak. The log wood has to be outside the reservoir and not inside the bag.

10.3.2. The installation of the Biogas Storage Reservoirs

Once the reservoirs are constructed, the battery of the reservoirs is installed. As mentioned before, two (valley / tropics zones) or rather three reservoirs (high altitude zones) are connected to a biogas storage battery.
How the reservoirs are connected, describes Figure 21.

The reservoirs are connected in series in the following way:
Directly before the t-fitting T1, the lock valve V1 is fitted. This valve has the function to block the line in the direction of the tube digester during cooking (See chapter 10.3.4). Between the t-fittings T2 and T3 the lock valve V2 is installed. If the battery just has two reservoirs, then instead of the t-fitting T3, the tube bend B1 is fitted. In the case of three reservoirs (high altitude zones), the lock valve Vxa between the t-fitting T3 and the tube bend B1 is installed. To reduce the cost, it is possible to dispense with the lock valve Vxa (This is e.g. the case in Bolivia).

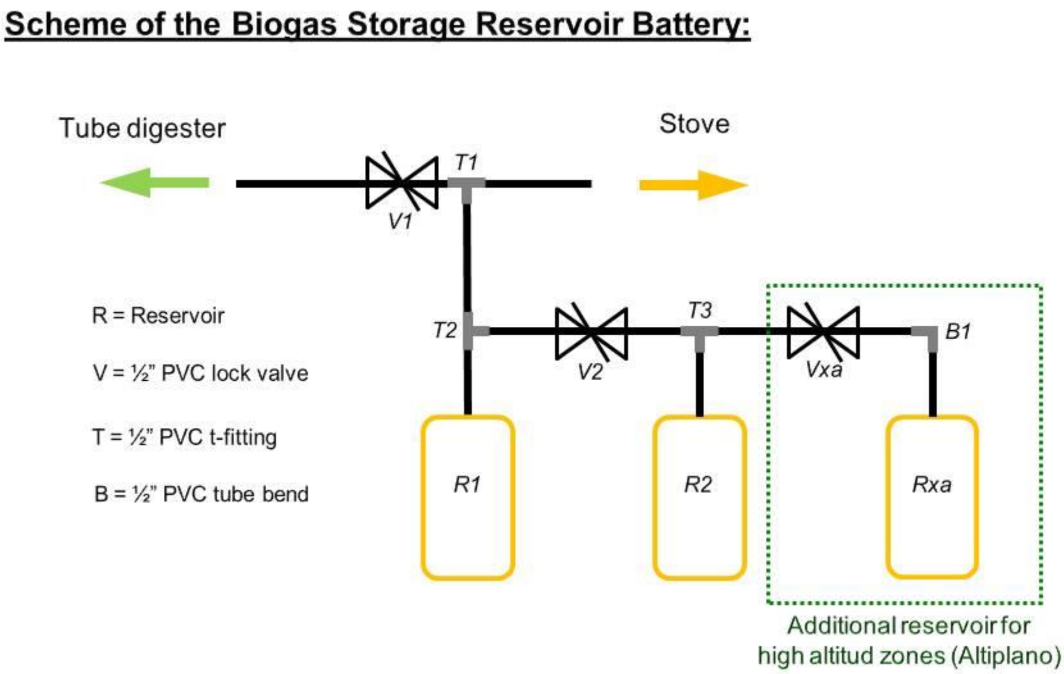

Figure 21: Scheme of the Biogas Storage Reservoirs

10.3.3. Fixing of the Biogas Storage Reservoir and the pressure weight

The reservoirs are fixed with a cord at a bar-construction like in Figure 23. The idea is to hang-up the reservoirs and to increase the necessary pressure in that manner, that the cord is eased down and the reservoir sinks by its own weight. This has the effect that the reservoir push's out the biogas towards the stove. To have a higher and constant pressure, an additional weight is installed. For that a rubber ring is used (Figure 22 & Figure 23), made by an old car wheel, which sinks synchronous with the re-servoir. To protect the reservoirs a bed on the floor below is constructed, like e.g. an old car wheel.

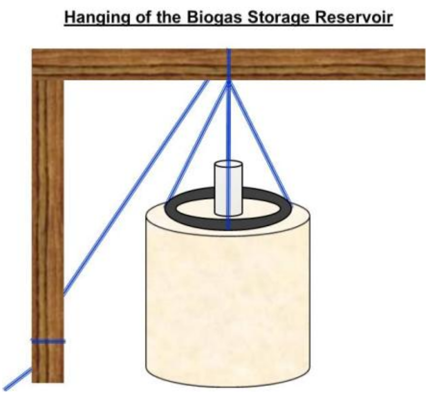

Figure 22: Example of the hanging of the reservoir

Figure 23: Fixed double reservoir battery with rubber ring for the pressure increasing

10.3.4. Operating of the Biogas Storage Reservoir

The Biogas Storage Reservoirs don't have just the function to store the biogas like a gas bottle; they have also the important function to supply the biogas-stove with a constant pressure during cooking.

During the cooking, only the biogas of the reservoirs is used. So the lock valve V1 (Figure 21) is closed, because any biogas should flow back to the tube digester. In the case of just two reservoirs the reservoir R2 is used first. The cord of the reservoir is eased down, so that the biogas is pushed out towards the stove. In the moment when the reservoir R2 is empty, the reservoir R1 is used. For that the lock valve V2 is closed, because the biogas can`t flow into the reservoir R2 and just towards the stove. In the case of three reservoirs, the reservoir Rxa is used first and then the reservoir R2 and so on. After a reservoir is empty and the corresponding lock valve is closed, this reservoir is hanged-up again. After cooking the lock valve V1 to Vxa is opened, so that new biogas can flow into the reservoirs.
The same procedure is also necessary by using a biogas-lamp.

Because this function of the reservoirs, it is important, that they are installed near by the kitchen and accessible. It shall be understood that the reservoirs are to protect against possible damages like stitches. If there are anymore biogas in the reservoirs, it can be used directly the biogas of the tube digester and the supply line.

11. General recommendations for the operation and maintains of the tube digester

11.1. The Biogas Stove

- To cook with biogas, it is to install a biogas stove. The stove should be installed in a place without wind like a closed ambience.
- When the flame of the biogas doesn´t has the color of a clear blue, it is to control the hydrogen sulfide filter in the t-fitting of the security valve.
- To reduce the cost, in Bolivia the tube digesters are added just with one stove actually. But it is recommended to provide the system with two stoves. It possible to connect a second stove later.

11.2. Daily charge of the tube digester

Every morning the tube digester should be charged with a substrate mix of fresh dung and water, so that there is enough biogas for 4 – 5 hours of cooking. The following Table 8 gives an example of the mix ratios of different animal dung's.

Animal	Dung per day	Water per day	Mix ratio
Cow	20 kg	55 l	1 : 2,5
Pig	15 kg	52,5 l	1 : 3,5

Table 8: Daily Substrate mix examples of different kinds of animal dung's

11.3. Protection of the tube digester against the sun and the damage by animals

- Around the tube digester it is recommended to install a safety fence or a protection wall (of adobe e.g.)
- In the valley- and tropics zones it is advisable to protect the tube digester against the solar radiation with a half shadow red or much better a roof.
- Digesters with a good roof and fence sustain significantly longer than digesters without, but this is coherent with higher investment costs.
- Also it is recommended to protect the in- and outlet of the digester against the incidence of indecomposable objects.

11.4. In the case of perforations of the tube digester

In the case of a perforation of the tube digester, it is possible to solve the problem.

- A tiny perforation can be repaired with a patch of a car tire.
- A middle perforation can be repaired by using a flange like the biogas-outlet closed by a plug.
- A mayor perforation can be repaired by the preparation of a metal gasket with a rubber packing. This is to adapt to the size of the perforation.

11.5. Recommendations for the lock valve and the security valve

- The first lock valve of maintenance (before the security valve), has to be unlocked every time. The exception to close / lock the valve consists in the maintenance of the biogas supply line. In the last resort the tube digester can break by a forgotten locked valve. This doesn´t mean a danger for human hurts, but an unnecessary losing of the digester.
  To avoid that somebody close the valve unwittingly, it is recommended to drop the crank of the lock valve and to fit it just for the maintenance.
- The security valve should be filled with 15 – 20 cm of water column. Without or not enough water, the biogas would flow out the system.

11.6. Maintenance of the biogas supply line

11.6.1. Accumulation of water

Sometimes it is possible that the biogas doesn´t reach the gas stove, because the supply line is blocked by water inside the PVC tube. It is recommended to dewater the supply line at least every two month. This procedure takes just about 15 minutes.

The following steps show how to let out the condensed water:

1. Fit the crank of the principal lock valve for maintenance and then close it.
2. Close the lock valve V1 (Figure 21) before the biogas storage reservoirs.
3. Open the screw plugs of the t-fittings (10.1 Accumulation of water) to let out the inside water.
4. Close the screw plugs of the t-fittings.
5. Open the maintenance lock valve and drop the crank.
6. Open the valve V1.

11.6.2. Replacement of the hydrogen sulfide filter

When the flame of the biogas stove has a ginger color and not a clear blue, this means that there are some impurities in the biogas, normally generated by the corroded filter, which is fitted in the t-fitting by the security valve (10.2. Security valve). It is recommended to replace the filter at least every 6 month.

1. Fit the crank of the principal lock valve for maintenance and then close it.
2. Close the lock valve V1 (Figure 21) before the biogas storage reservoirs.
3. Drop the security valve.
4. Remove the 20 cm long ½” PVC Tube which is inside the bottle from the t-fitting.
5. Remove the “old” filter and renew the steel wool.
6. Screw the PVC tube.
7. Fit the security valve and fill it up with water (15 – 20 cm)
8. Open the maintenance lock valve and drop the crank.
9. Open the valve V1.

11.7. What to do, if there is no biogas

In the case of any or low biogas supply, it is to control the following facts:

- Control of the inlet and outlet of the tube digester.
  It is possible in the case of a poor leveled inlet/outlet, or an irregular charge, that the slurry doesn´t move enough, so that there is generating a hard crust that doesn´t let out the slurry. In this case it is to destroy the crust very carefully without damaging the tube digester.
- Control of perforations of the polyethylene of the tube digester. In the case of perforations see chapter 11.4 “In the case of perforations of the tube digester”.
- Control of biogas leakage at the connections of the supply line.

11.8. The slurry / organic fertilizer

The fertilizer should be collected in a chamber which protects the out flowed slurry against the solar radiation and impurities. Especially the solar radiation has the property to reduce the quality of the organic fertilizer.

The application of the organic fertilizer is a wide graded theme, which should deserve its own manual. By this reason the manual doesn´t respond further to that topic to avoid blowing up this document.